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Non-conscious recognition of emotional body language

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Patients with cortical blindness can reliably perceive some facial expressions even if they are unaware of their percept. We examined whether emotional body language may also be recognized in the absence of the primary visual cortex and without conscious stimulus perception. We presented emotional and neutral body images in the blind field of a patient with unilateral striate cortex damage. Using functional magnetic resonance imaging, we measured activation following presentation

to the blind hemifield of whole body images (happy, neutral) with the face blurred. Unseen happy body images selectively activated area MT and the pulvinar nucleus of the thalamus, while unseen instrumental neutral body images activated the premotor cortex. Our results show that in the absence of the striate cortex implicit bodily emotion perception may be possible. *NeuroReport* 17:583–586 © 2006 Lippincott Williams & Wilkins.

Keywords: action representation, blindsight, emotion, non-conscious emotion, whole body expression

Introduction

Current models of emotion perception hold that emotional information is processed by a network involving both cortical and subcortical structures [1–3]. The importance of subcortical pathways in facial expression processing is largely supported by findings from patients with primary visual cortex lesions [4–6]. These pathways, not based on projections of the retina to the striate cortex via the lateral geniculate nucleus, but involving the superior colliculus and the pulvinar nucleus of the thalamus, provide an alternative visual route through which visual areas anterior to the striate cortex can be reached in case of damage to primary visual centers. The ability to process some emotional signals in the absence of normal vision is called affective blindsight [6,7].

Recent findings indicate that areas typically involved in the recognition of facial expressions also play a role in the recognition of biological non-facial stimuli. For example, viewing biological movement patterns experienced as pleasant activates the amygdala [8]; visual perception of biological motion activates areas in the occipital and fusiform cortex [9]. Consistent with these findings, we recently observed that the amygdala and the fusiform cortex play an important role in recognizing whole body expressions of emotion shown with the face completely blurred, suggesting a significant degree of overlap between the neural basis of processing facial expressions and emotion expression by the whole body [10–12].

Besides the areas common to processing facial expressions and emotional body language, including the amygdala, the fusiform cortex, the inferior temporal gyrus and the

somatosensory cortex [3], other areas are also involved in viewing body expressions. These areas are more related to action representation and motor activity, and are strongly modulated by whether actions are performed neutrally or also expressing an emotion (fear, happiness) (inferior and middle frontal gyri, precentral gyrus, inferior parietal lobule, supplementary motor area) [12]. Interestingly, activations triggered by presenting happy body images contrasted with neutral body images generate increased activation in early visual areas consistent with findings of emotional modulation of these areas [13]. Although the studies used still images, there was clear evidence for implicit motion perception, which was strongest for body expressions of fear. Directly relevant for the present study, we also showed that emotional body images activate the pulvinar [12], as previously observed for images of fearful faces [14].

In line with the focus on facial expressions in mainstream emotion research, investigations of affective blindsight revealing the role of a superior colliculus–pulvinar subcortical route have been centered on facial expressions. So far, no positive evidence exists to show that patients with cortical blindness can recognize other affective stimuli besides faces known to activate amygdalae in normal viewers. For example, affective pictures do not activate amygdala in these hemianopic patients as they do in normal individuals [14]. This raises the question addressed in the present study of whether the comparatively large-scale features of whole body expressions of emotion can be processed by a subcortical visual route. A major function of this route is to sustain rapid orientation and detection of potentially dangerous signals based on a type of coarse

visual analysis as can be performed by the superior colliculus [15]. The possibility that there exists a non-conscious and non-lateral geniculate nucleus-based recognition of emotional bodies is important for understanding the functional contribution of this route in human social communication. Here we investigated the neural basis of unconscious perception of emotional body images in a study participant (G.Y.) with complete left-side hemianopia due to a lesion of the primary visual cortex.

It is known from the neuropsychological literature that neurological damage tends to affect the least emotion recognition of 'happy' signals. These are the most robust, possibly because they elicit the highest arousal; they are associated with more movement and invite the most mimicry [16]. Therefore, for this first investigation of non-consciously processed emotional body language, we used neutral vs. happy body stimuli. As a result of the left hemisphere striate cortex lesion of G.Y., stimuli were presented to the right blind hemifield. These testing conditions are different from the central presentation in normal individuals that has been used so far, and therefore some minor differences from the results in normal individuals are to be expected. First, lateral presentation may induce more implicit movement perception because of the relative specialization of subcortical structures such as the superior colliculus for movement detection. Second, emotional stimuli may elicit stronger brain activations under conditions of no awareness than when individuals are aware.

Methods

Study participant

Patient G.Y. is a 46-year-old man who sustained damage to the posterior left hemisphere of his brain by head injury (a road accident) when he was 7 years old. The lesion (see [17] for an extensive structural and functional description of the lesion) invades the left striate cortex (i.e. medial aspect of the left occipital lobe, slightly anterior to the spared occipital pole, extending dorsally to the cuneus and ventrally to the lingual, but not the fusiform gyrus) and surrounding the extra-striate cortex (inferior parietal lobule). The location of the lesion is functionally confirmed by perimetry field tests (see [17] for a description of G.Y.'s perimetric field). He has macular sparing extending 3° into his right (blind) hemifield. Preliminary testing ensured that throughout all experiments the materials and presentation conditions did not give rise to the awareness that a stimulus was presented in the blind field.

Behavioral experiment

The behavioral study was run separately from the functional magnetic resonance imaging experiment after a 1-week delay. It involved two sessions, the first one with presentations in the blind field, and the second one in the intact field. Stimuli were the same as those used in the functional magnetic resonance imaging study. G.Y. was asked to maintain fixation on the central cross, and the direction of his gaze was monitored throughout the testing by one of the experimenters. His task was to indicate, by pressing one of two response buttons, whether the presented body expressed happiness or a neutral state. Stimulus presentation was always accompanied by a 300-ms tone signaling the presence of an image in either field. In each session, 160 pictures were presented, half of them with the body expressing happiness, and the other half neutral, in random order.

Functional magnetic resonance imaging experiment

Functional magnetic resonance images of brain activity of G.Y. were collected in a 3-T high-speed echoplanar imaging device (Siemens, Erlangen, Germany) using a quadrature head coil. Informed written consent was obtained before the scanning session, and the Massachusetts General Hospital Human Studies Committee approved all procedures. Image volumes consisted of 45 contiguous 3-mm-thick slices covering the entire brain (TR=3000 ms, 3.125 mm by 3.125 mm in plane resolution, 128 images per slice, TE=30 ms, flip angle 90°, FOV=20 × 20 cm, matrix=64 × 64).

Materials

Stimuli consisted of still images obtained from video recordings of 16 semi-professional actors (eight women, age 22–35 years). Actors performed meaningful actions that were emotionally neutral or expressed happiness using the whole body. A full description of the stimuli is given in [12].

In the scanner, a total of 16 grayscale pictures (eight happy and eight neutral body postures) were used in two separate runs in an AB-blocked design (happy vs. neutral). A block lasted 24 s, during which the pictures were presented for 300 ms, followed by a blank interval with only a fixation cross for 1700 ms. Images were presented laterally at 5.5° between the inner edge of the image and the fixation point in the right (blind) hemifield. Mean size of the pictures was 5 cm width by 8 cm height (sustaining a visual angle of 4.7° horizontally by 7.7° vertically). Preliminary testing ensured that the presentation conditions did not give rise to an awareness of the presence of a stimulus in the blind field.

Data analysis

We used the Fuesuroer package and the techniques used in our analysis are similar to those described previously [12]. Each functional run was first motion-corrected with Analysis of Functional NeuroImaging (AFNI) [18] and spatially smoothed by using a three-dimensional Gaussian filter with a full-width at half-maximum of 6 mm. The mean offset and linear drift were estimated and removed from each voxel. The spectrum of the remaining signal was computed using the fast Fourier transform at each voxel. The task-related component was estimated as the spectral component at the task fundamental frequency. The noise was estimated by summing the remaining spectral components after removing the task harmonics and those components immediately adjacent to the fundamental. The phase at the fundamental was used to determine whether the blood oxygen-level-dependent signal was increasing in response to the first stimulus (positive phase) or the second stimulus (negative phase).

Results

Behavioral data

Substantial recognition of the presented expression was obtained in both visual fields, 87% correct identifications in the (intact) left field and 67% in the (blind) right field. The important finding is that the blind field recognition score, 108 correct in 160 presentations, is significantly above chance level (50%) ($\chi^2=10.1$, $P<0.01$).

Brain imaging results

Presentation of bodies expressing happiness compared with bodies performing neutral actions in the blind (right) visual

field (Figs 1 and 2) resulted in the activation of the right thalamus pulvinar complex (10, -34, 5), the right anterior medial temporal lobe (29, -13, -25), the right inferior temporal sulcus (52, -38, -16), the right superior temporal sulcus (46, -55, 7) and in the left occipital cortex, between the lateral and the inferior occipital sulcus, in the region corresponding to MT (-42, -74, -20). In addition, the inferior parietal lobules were activated bilaterally (-30, -70, 42 and 25, -75, 42). Bodies performing neutral actions activated the premotor cortex in the left hemisphere (-34, -16, 30).

Discussion

Our study is the first investigation of the non-conscious perception of emotional body language in a patient with unilateral striate cortex damage. Happy body images were contrasted with images of neutral instrumental actions in order to obtain an appropriate control condition with a close similarity between the overall physical stimulus properties.

Our behavioral results show convincingly that G.Y. can reliably discriminate between stimulus categories shown to his blind field. Our brain imaging results clearly indicate that G.Y. processes the stimuli presented in the blind field and that the activity observed in the brain centers is condition specific. This selective stimulus sensitivity is consistent with the behavioral results of correct categorization in both the intact and the blind fields. Combining the behavioral success in discriminating between happy and instrumental stimuli and the selective brain activity for these categories allows us to conclude that, to some extent, emotional body language can be processed in the absence of the striate cortex and of awareness of the visual stimulus. Since this study, we have carried out extensive experiments

in blindsight patient D.B. confirming non-conscious recognition of bodies expressing fear and happiness [19] by using an indirect testing method whereby the participant rated the stimulus in the intact field while an unnoticed stimulus was presented simultaneously in the blind field.

Activation in visual area MT is unlikely to be caused by subjective motion perception due to transient onsets, as there was no difference in onset characteristics between the two image categories. Thus, our results seem to indicate a relationship between emotion recognition and implied movement perception.

What is the neural basis of body perception in the absence of the striate cortex and how does activity in the observed areas contribute to it? Activation for happy body images was found in area MT in the left hemisphere contralateral to the lesion, a finding that is consistent with a previous report of MT activity for unseen movement in this same patient [20]. Previous reports indicate that area MT shows increased signal intensity to apparent motion stimuli as compared with flickering control conditions, and with apparent motion of figures defined by illusory contours [20]. Area MT contains a high proportion of directionally selective neurons, as demonstrated by animal studies [21] and is selectively involved in passively viewing motion displays. The anatomical location provided in the study cited above is very similar to the one seen here, and our results are consistent with the surprisingly strong MT activity evoked by the blind-field stimulus presentation [20].

The observed activity in the pulvinar is consistent with the role of the subcortical visual pathway (superior colliculus-pulvinar) already reported for faces expressing fear [2,6,7]. Against this background, the activity in MT is particularly

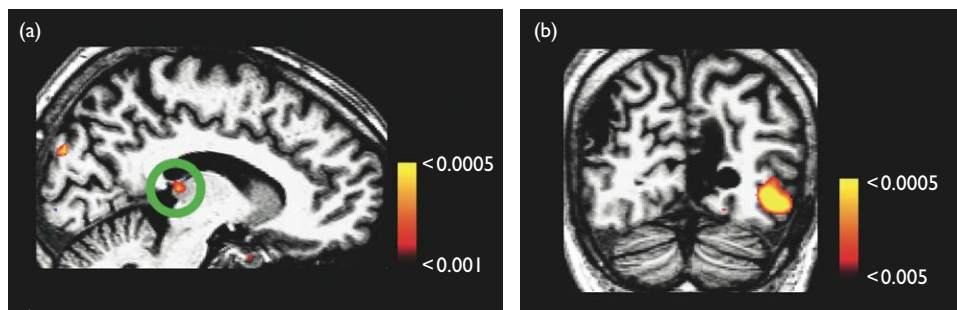


Fig. 1 Statistical maps of brain activation in response to bodies expressing happiness compared with neutral bodies presented in the blind visual field. (a) Activation in the right pulvinar (green circle). (b) Activation in the left MT area.

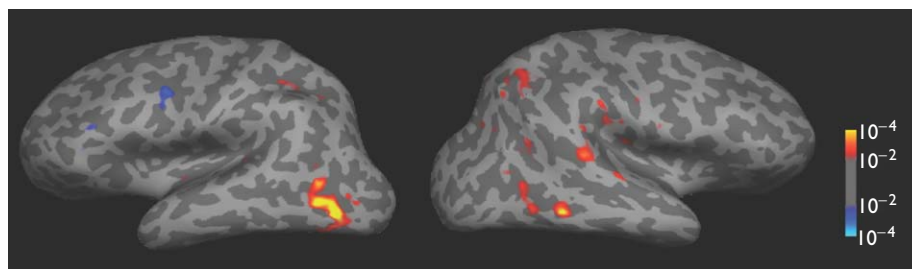


Fig. 2 Statistical maps of brain activation in response to bodies expressing happiness compared with bodies performing neutral actions presented in the blind visual field. The hemispheres are inflated in order to show the sulci (darker shade of gray) and the gyri (lighter shade of gray). Areas that were activated by bodies expressing happiness are displayed in red ($P < 0.01$) to yellow ($P < 0.0001$). Areas that were activated by bodies performing neutral actions are displayed in blue ($P < 0.01$) to cyan ($P < 0.0001$). Activation for happy body stimuli was found in area MT in the left hemisphere, in the right inferior and superior temporal sulcus, the right anterior medial temporal lobe, and in the inferior parietal lobule bilaterally. Bodies performing neutral actions activate the left premotor cortex. In contrast with our normal data, no activity was observed in the primary visual cortex for the happy body condition, but this was obviously consistent with the striate cortex lesion of G.Y.

interesting because of the connectivity between the superior colliculus and MT, consistent with an important role of MT in subcortical motion processing. This subcortically driven motion-processing activity may be part of a broader subcortical pathway for processing social signals [22,23].

We observed emotion-specific activation in the right inferior and superior temporal sulcus, structures that are known to play a role in the processing of biological movement [24]. Activity was also present bilaterally in the inferior parietal lobules that belong to the mirror neuron system [25], underscoring that the bodies represented in the stimuli were encoded similarly as in normal viewers. In contrast to the activity generated by the bodies expressing happiness, bodies performing neutral actions activated left premotor cortex, an area often found in studies using neutral action stimuli and playing a role in action representation [12,26].

It is interesting to compare the present data with earlier results obtained with facial expressions in blindsight patients. Previous behavioral experiments indicated that still faces could not be recognized [7]. Here, however, we observed that categorization of still body images is well within reach in the absence of the striate cortex. The present finding of category-specific activity for happy vs. neutral instrumental stimuli points to the importance of the motion-processing area, and suggests that this is more strongly addressed by body than by face stimuli. Note, however, that in our previous study with normal viewers, no selective MT activity was observed. We conjecture that this may be because implied motion and action were common to both emotional and neutral conditions. It is interesting to note here how, at the level of subcortical vision, these motion-detection and action representation-related structures can be differentiated. Happy body stimuli trigger more activity related to motion processing (superior colliculus–pulvinar–MT) while non-conscious instrumental actions trigger activity indicating representation of action.

Conclusion

This study provides the first evidence of the brain's ability to process emotional body language unconsciously and without reliance on the primary visual cortex. Our data significantly extend the available evidence of a role of subcortical structures in emotion processing.

The present results suggest that non-conscious recognition of emotional body language may be based on processing of emotion-specific implicit movement, and our study extends the functional significance of a subcortical visual pathway hitherto only known to process facial expressions to emotional body language.

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